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Indian Standard

पावर गुणता के मापन एवं परीक्षण हेतु — पद्धतियाँ

Power Quality Measurement and Monitoring — Methods

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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Basic Electrotechnical Standards and Power Quality Sectional Committee had been approved by the Electrotechnical Division Council.

The need for this standard is owing to growing digital economy driven by power electronic devices which themselves are very sensitive to power quality variations as well as polluting the power lines and posing a major challenge (current distortions which are detrimental to power system at large) to national grid in maintaining the voltage and current profile. The country's focus on "quality power" delivery has necessitated power quality monitoring at all levels, along with a standardized approach to power quality measurement and empowering utilities, regulators and consumers to make decisions that are data driven.

This standard lays down the requirements for measurement and monitoring of power quality. Considerable assistance has been derived from IEC 61000-4-7, IEC 61000-4-15, IEC 61000-4-30 standards for the preparation of this standard. Measurement methods, maximum measurement uncertainty, measurement ranges, time aggregation have been modified to suit to Indian requirements.

In formulation of this standard, assistance has been derived from the following publications:

IS No./Other Standards	*Title*
IS 14700 (Part 4/Sec7) : 2017/ IEC 61000-4-7 : 2009	Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 7 General guide on harmonic and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto (*first revision*)
IS 17036 : 2018	Distribution system supply voltage quality
IEC 60050 (all parts)	International electrotechnical vocabulary (IEV) (available at www.electropedia.org)
IEC 61000-2-4 : 2002	Electromagnetic compatibility (EMC) — Part 2-4: Environment — Compatibility levels in industrial plants for low-frequency conducted disturbances
IEC/TR 61000-2-8 : 2002	Electromagnetic compatibility (EMC) — Part 2-8: Environment — Voltage dips and short interruptions on public electric power supply systems with statistical measurement results
IEC/TR 61000-2-14 : 2006	Electromagnetic compatibility (EMC) — Part 2-14: Environment — Over voltages on public electricity distribution networks
IEC 61000-3-3 : 2013	Electromagnetic compatibility (EMC) — Part 3-3: Limits — Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection
IEC 61000-3-8 : 1997	Electromagnetic compatibility (EMC) — Part 3: Limits, Section 8: Signalling on low-voltage electrical installations — Emission levels, frequency bands and electromagnetic disturbance levels
IEC 61000-4-15 : 2010	Electromagnetic compatibility (EMC) — Part 4-15: Testing and measurement techniques — Flickermeter — Functional and design specifications
IEC 61000-4-30 : 2015	Electromagnetic compatibility (EMC) — Part 4-30: Testing and measurement techniques — Power quality measurement methods

(*Continued on third cover*)

Indian Standard

POWER QUALITY MEASUREMENT AND MONITORING — METHODS

1 SCOPE

1.1 This standard defines the methods for measurement and monitoring of results for power quality parameters at network user's supply terminals in distribution system with a declared fundamental frequency of 50 Hz. All cycle times are with respect to fundamental frequency of 50 Hz.

1.2 The power quality parameters considered in this standard are frequency, magnitude of the supply voltage, rapid voltage change, flicker, supply voltage unbalance, voltage harmonics, voltage inter harmonics, mains signaling voltage, voltage interruptions, supply voltage dips and swells, current magnitude, current harmonics, current inter harmonics, current unbalance.

2 REFERENCES

The standards listed in Annex A contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards.

3 TERMINOLOGY

For the purposes of this document, the following terms and definitions apply.

3.1 Crest Factor — The crest factor is defined as the ratio of the peak instantaneous value and rms value.

3.2 Current Unbalance — Condition in a polyphase system in which the rms values of the line currents (fundamental component), or the phase angles between consecutive line currents are not all equal.

3.3 Declared Supply Voltage *U*c — Declared supply voltage *U*c shall be the voltage at the consumers supply terminals declared by the supplier of electrical energy. *U*c is usually equal to the nominal voltage *U*n.

NOTE — Declared supply voltage *U*c is usually equal to the nominal voltage *U*n but it may differ by agreement between the network user and the network operator.

3.4 Flicker — The impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time.

NOTE — Flicker is caused under certain conditions by voltage fluctuation changing the luminance of lamps.

3.5 Flicker Severity — The intensity of flicker annoyance evaluated by the following quantities:

a) Short term severity (P_{st}) measured over a period of 10 min; and

b) Long term severity (P_{lt}) calculated from a sequence of twelve P_{st} values over a 2 h time interval, according to the following expression:

$$P_{lt} = \sqrt[3]{\sum_{i=1}^{12} \frac{{P_{sti}}^3}{12}}$$

where

P_{sti} (I = 1, 2, ….12) are twelve consecutive values.

3.6 Harmonic Current — Sinusoidal component of current waveform having a frequency that is an integral multiple of the fundamental frequency.

3.7 Harmonic Voltage — The sinusoidal voltage with a frequency equal to an integer multiple of the fundamental frequency of the supply voltage.

NOTES

1 Application – Harmonic voltages can be evaluated:

i) Individually by their relative amplitude (u_h) which is the harmonic voltage related to the fundamental voltage (u_1), where h is the order of the harmonic.

ii) Globally, for example by the total harmonic distortion factor THD, calculated using following expression:

$$THD = \sqrt{\sum_{h=2}^{50} (u_h)^2}$$

2 Harmonics of the supply voltage are caused mainly by network users' non- linear loads connected to all voltage levels of the supply network. Harmonic currents flowing through the network impedance give rise to harmonic voltages. Harmonic currents and network impedances and thus the harmonic voltages at the supply terminals vary in time.

3.8 High Voltage (HV) — Voltage whose nominal rms value is 33 kV < $U_n \leq$ 220 kV.

3.9 Hysteresis — Difference in magnitude between the start and end thresholds.

NOTE — The purpose of hysteresis in the context of power quality measurements is to avoid counting multiple events when the magnitude of the parameter oscillates about the threshold level.

3.10 Inter-Harmonic Component — Spectral component with a frequency between two consecutive harmonic frequencies.

3.11 Interruption Threshold — Voltage magnitude specified for the purpose of detecting the start and end of a voltage interruption.

3.12 Low Voltage (LV) — Voltage whose nominal rms value is $U_n \leq 1$ kV.

3.13 Mains Signalling Voltage — Signal superimposed on the supply voltage for the purpose of transmission of information in the public supply network and to network users' premises.

NOTES — Three types of signals in the public supply network can be classified:

1 Ripple control signals: superimposed sinusoidal voltage signals in the frequency range 110 Hz to 3 000 Hz.

2 Power-line-carrier signals: superimposed sinusoidal voltage signals in the frequency range 3 kHz to 148.5 kHz.

3 Mains marking signals: superimposed short time alterations (transients) at selected points of the voltage waveform.

3.14 Medium Voltage (MV) — The voltage whose nominal rms value is 1 kV < $U_n \leq$ 33 kV.

3.15 Network Operator — Party responsible for operating, maintain and develop the supply network for ensuring its long-term ability to meet expected demands for electricity supply.

3.16 Network User — Party being supplied by or supplying to an electricity supply distribution network.

3.17 Nominal Frequency (of the Supply Network) — Nominal value of the frequency of the supply voltage.

3.18 Nominal Voltage (of the Supply Network) — U_n value of voltage by which the electrical installation or part of the electrical installation is designated and identified.

3.19 Over Deviation — Difference between the measured value and the nominal value of a parameter, only when the measured value of the parameter is greater than the nominal value.

3.20 Point of Common Coupling (PCC) — The point on a public power supply network, electrically nearest to a particular load, at which other loads are, or could be, connected.

3.21 Power Quality — Characteristics of the electricity at a given point on an electrical system, evaluated against a set of reference technical parameters.

3.22 Reference Voltage (for Interruptions, Voltage Dips and Voltage Swells Evaluation) — Value specified as the base on which residual voltage, thresholds and other values are referred in per unit or percentage terms.

NOTE — For the purpose of this standard, the reference voltage is the nominal or declared voltage of the supply system.

3.23 Rapid Voltage Change — Single rapid variation of the rms value of a voltage between two consecutive levels which are sustained for definite but unspecified durations and during which the rms voltage does not exceed the dip/swell thresholds.

3.24 Supply Interruption — Condition in which the voltage at the supply terminals is lower than 5 percent of the reference voltage.

NOTES

1 Supply interruptions can be classified as:

a) Prearranged, when network users are informed in advance; and
b) Accidental, caused by permanent or transient faults, mostly related to external events, equipment failures or interference.

2 An accidental interruption is classified as:

a) A long interruption (longer than 3 min); and
b) A short interruption (upto and including 3 min).

For polyphaser systems, an interruption occurs when the voltage falls below 5 percent of the reference voltage on all phases (otherwise, it is considered to be a dip).

3.25 Supply Terminal — Point in a distribution system designated as such and contractually fixed, at which electrical energy is exchanged between network user and distribution network licensee.

3.26 Voltage Dip — Temporary reduction of the rms voltage at a point in the electrical supply system below a specified start threshold.

3.27 Voltage Dip Duration — Time between the instant at which the rms voltage falls below the start threshold and the instant at which it rises to the end threshold.

3.28 Voltage Dip End Threshold — The rms value of the voltage specified for the purpose of defining the end of a voltage dip.

3.29 Voltage Dip Residual Voltage — Minimum value of rms voltage recorded during a voltage dip.

3.30 Voltage Dip Start Threshold — The rms value of the voltage specified for the purpose of defining the start of a voltage dip. For the purpose of this standard, the dip start threshold is equal to 90 percent of the reference voltage.

3.31 Voltage Fluctuation — Series of voltage changes or a cyclic variation of the voltage envelope.

3.32 Voltage Swell (Temporary Power Frequency Overvoltage) — Temporary increase of the rms voltage above a specified start threshold.

3.33 Voltage Swell Duration — Time between the instant at which the rms voltage at a particular point of an electricity supply system exceeds the start threshold and the instant at which it falls below the end threshold.

3.34 Voltage Swell End Threshold — The rms value of the voltage on an electricity supply system specified for the purpose of defining the end of a voltage swell.

3.35 Voltage Swell Start Threshold — The rms value of the voltage on an electricity supply system specified for the purpose of defining start of a voltage swell. For the purpose of this standard, the swell start threshold is equal to 110 percent of the reference voltage.

3.36 Voltage Unbalance — Condition in a polyphase system in which the rms values of the line-to-line voltages (fundamental component), or the phase angles between consecutive line voltages, are not all equal.

3.37 Voltage Variation — Increase or decrease of rms voltage normally due to load variations.

3.38 Measurement Uncertainty — Parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand.

3.39 Root-Mean-Square Value (rms) — Square root of the arithmetic mean of the squares of the instantaneous values of a quantity taken over a specified time interval and a specified bandwidth.

3.40 RMS Voltage Refreshed Each Half-Cycle $U_{rms}(½)$ — Value of the rms voltage measured over 1 cycle, commencing at a fundamental zero crossing, and refreshed each half-cycle.

3.41 RMS Voltage Refreshed Each Cycle $U_{rms}(1)$ — Value of the rms voltage measured over 1 cycle and refreshed each cycle.

NOTE — In contrast to $U_{rms}(½)$, this technique does not define when a cycle commences.

3.42 Time Aggregation — Combination of several sequential values of a given parameter (each determined over identical time intervals) to provide a value for a longer time interval.

3.43 UTC Coordinated Universal Time — Time scale which forms the basis of a coordinated radio dissemination of standard frequencies and time signals which corresponds exactly in rate with international atomic time but differs from it by an integral number of seconds.

3.44 Under Deviation — Absolute value of the difference between the measured value and the nominal value of a parameter, only when the measured value of the parameter is lower than the nominal value.

4 GENERAL REQUIREMENTS

4.1 Classes of Measurement

For each parameter measured two classes are defined in the following Table 1.

Table 1 Classes of Measurement

(*Clause* 4.1)

Sl No. (1)	Class Name (2)	Class Description (3)	Examples of Measurement Applications Falling into (4)
i)	A	For precise measurement applications	For contractual applications that may require resolving disputes or verifying compliance with standards.
ii)	S	For statistical applications	For example, statistical surveys or power quality assessment, possibly with a limited subset of parameters.

NOTES

1 In this standard, “A” stands for “Advanced”, and “S” stands for “Surveys”.

2 An instrument complying to all mandatory PQ parameters for particular class to be stated as full compliance instrument. For example, instrument complying to Class A for all mandatory PQ parameters shall be stated as full Class A compliance PQ instrument.

4.2 Measurement Aggregation Over Time Interval

The basic measurement time interval for parameter magnitudes (voltage magnitudes, harmonics, interharmonics and unbalance) shall be a 10 cycle time interval. The 10 cycle measurement shall be re-synchronized at every UTC (coordinated universal time) 10 min tick.

The 10 cycle values are then aggregated over 3 additional intervals:

a) 150 cycle interval;
b) 10 min interval; and
c) 2 h interval.

Except for flicker measurements, aggregations shall be performed using the square root of the arithmetic mean of the squared input values. For flicker measurement the aggregation algorithm is provided by IEC 61000-4-15 shall be used.

4.3 Flagging

During a dip, swell or interruption, the measurement algorithm for other parameters (for example, frequency measurement) might be influenced. The flagging concept avoid counting a single event more than once in different parameters (for example, a single dip as both a dip and a frequency variation) and indicates that an aggregated value might be unreliable. Flagging concept is applicable during measurement of frequency, voltage magnitude, flicker, supply voltage unbalance, voltage harmonics, voltage inter-harmonics, mains signalling and measurement of under deviation and over deviation parameters.

Flagging is only triggered by dips, swells, and interruptions. The detection of dips and swells is dependent on the threshold selected by the user, and this selection will influence which data are flagged.

If during a given time interval any value is flagged, the aggregated value which includes that value is to be flagged. The flagged value are stored and also included in the aggregation process.

4.4 Time-Clock Uncertainty

Time-clock uncertainty is defined relative to coordinated universal time (UTC) is listed in the following Table 2.

Table 2 Time-Clock Uncertainty

(*Clause* 4.4)

Sl No. (1)	Class Name (2)	Maximum Allowed Uncertainty (3)
i)	A	± 20 ms regardless of the total time interval
ii)	S	± 5 s per 24 h time interval

NOTES

1 In The performance in Class A can be achieved, for example, through a synchronization procedure applied periodically during a measurement campaign, through a GPS receiver, or through reception of transmitted radio timing signals or by using network timing signals.

2 When synchronisation by an external signal becomes unavailable, the time tagging tolerance shall be better than ± 1 s per 24 h time interval; however, this exception does not eliminate the requirement for compliance stated in table.

5 POWER QUALITY MEASUREMENTS METHODS

This clause contains the measurement methods to be applied to each power quality parameter considered by this standard.

5.1 Frequency

The frequency reading shall be obtained every 10 s. The fundamental frequency shall be evaluated as the number of integral cycles counted during the 10 s time clock interval divided by the cumulative duration of the integer cycles.

For frequency, measurement methods given in IEC 61000-4-30 frequency shall be used.

NOTE — As frequency may not be exactly 50 Hz within the 10 s time clock interval, the number of cycles may not be an integer number.

Time aggregation, maximum uncertainties and mandatory minimum measuring ranges to be used are listed in the following Table 3.

5.2 Magnitude of Supply Voltage

Measurement of this parameter shall be the rms value of the voltage magnitude over a 10 cycle time interval.

NOTES

1 This specific measurement method is used for quasi-stationary signals and is not used for the detection and measurement of disturbances: dips, swells, voltage interruptions and transients.

2 The rms value includes, by definition, harmonics, inter harmonics, mains signalling etc.

Mandatory minimum measuring ranges, maximum uncertainties and time aggregation to be used are listed in the following Table 4.

5.3 Single Rapid Voltage Changes

The measurement methods, range and uncertainty to be applied to this parameter shall comply with IEC 61000-4-30.

5.4 Flicker

The measurement methods to be applied to this parameter shall comply with IEC 61000-4-15 where Class F3 applies as the minimum requirement.

But for Class A, Class F3 should not be used for new designs and Class F1 is recommended.

Mandatory minimum measuring ranges, maximum uncertainties and time aggregation to be used are listed in the following Table 5.

5.5 Supply Voltage Unbalance

Unbalance measurements apply only for 3 phase systems. The supply voltage unbalance is evaluated using the method of symmetrical components.

The negative sequence unbalance ratio u_2 is evaluated by:

$$u_2 = \frac{U_2}{U_1} \times 100\ \% = \frac{\text{zero sequence}}{\text{positive sequence}} \times 100\ \%$$

The zero-sequence unbalance ratio u_0 is evaluated by:

$$u_0 = \frac{U_0}{U_1} \times 100\ \% = \frac{\text{zero sequence}}{\text{positive sequence}} \times 100\ \%$$

where

U_2 = negative sequence component;
U_1 = positive sequence component; and
U_0 = zero sequence component.

The fundamental component of the voltage input signal shall be measured over a 10 cycle time interval for 50 Hz power systems.

Mandatory minimum measuring ranges, maximum uncertainties and time aggregation to be used are listed in the following Table 6.

NOTE — Any other methods that can be shown to be mathematically equivalent to the given equations are allowed.

5.6 Harmonic Voltages

The basic measurement of voltage harmonics shall be the one defined in IEC 61000-4-7 according with the following Table 7 at least up to the 40th order for Class II and 50th order for Class I.

If the total harmonic distortion is calculated, then it shall be calculated as the subgroup total harmonic distortion (THDSY), defined in IEC 61000-4-7.

Mandatory minimum measuring ranges, maximum uncertainties and time aggregation to be used are listed in the following Table 8.

5.7 Interharmonic Voltages

The measurement methods, range and uncertainty to be applied to this parameter shall comply with IEC 61000-4-30.

5.8 Mains Signalling Voltage

The reference measurement method of signal voltages shall be selected in accordance with the following Table 9.

Mains signalling voltage measurement shall be based on either the corresponding 10 cycle rms value interharmonic bin; or the root of the sum of the squares of the 4 nearest 10 cycle rms value interharmonic bins. For example, a 316.67 Hz ripple control signal in a 50 Hz power system shall be approximated by a root of the sum of the squares of 310 Hz, 315 Hz, 320 Hz and 325 Hz bins, available from the DFT performed on a 10 cycle time interval.

NOTE — The first method is preferred if the specified frequency is in the centre of a DFT bin. The second method is preferred if the frequency is not in the centre of a bin.

The beginning of a signalling emission shall be detected when the measured value of the concerned interharmonic exceeds the detection threshold.

The detection threshold above 0.3 percent U_c as well as the length of the recording period up to 120 s shall be adopted.

Signal voltage measuring ranges, uncertainty and time aggregation for Class A and Class S are defined in the following Table 10.

5.9 Voltage Interruptions

A voltage interruption begins when the U_{rms} voltage falls below the voltage interruption threshold and ends when the U_{rms} voltages are equal to or above the voltage interruption threshold plus the hysteresis voltage.

The voltage interruption threshold and the hysteresis voltage are both set by the user according to the application.

The basic measurement U_{rms} of voltage interruptions shall be in accordance with the following Table 11.

The start time of a voltage interruption shall be the time stamped with the time of the start of the U_{rms} that initiated the event, and the end time of the voltage interruption shall be the time stamped with the time of the end of the U_{rms} that ended the event.

Mandatory minimum measuring ranges, maximum uncertainties and aggregation time to be used are listed in the following Table 12.

5.10 Supply Voltage Dips and Swells

The basic measurement U_{rms} of a voltage dip and swell shall be in accordance with the following Table 13.

The duration of a voltage dip or a voltage swell shall be calculated as the time difference between the start time and the end time of the voltage event considering that:

a) A voltage dip begins when one the U_{rms} voltage falls below the dip threshold and ends when all the U_{rms} voltages are equal to or above the dip threshold plus the hysteresis voltage.

b) A voltage swell begins when one the U_{rms} voltage rises above the swell threshold, and ends when all the U_{rms} voltages are is equal to or below swell threshold minus the hysteresis voltage.

NOTE — The threshold and the hysteresis voltages are both set by the application or the system standard for example IS 17036. According to IS 17036, the dip threshold is the percentage of declared supply voltage U_c.

Mandatory minimum measuring ranges, maximum uncertainties, and aggregation time to be used are listed in the following Table 14.

Time aggregation is not applicable.

5.11 Magnitude of Current

For Class A, measurement of this parameter shall be the rms value of the current magnitude over a 10 cycle time interval.

For Class S, manufacturer shall specify the rms measurement method and time interval used.

The manufacturer shall specify a full-scale rms current, taking into account a minimum ratio between peak instantaneous value and rms value of 3.0.

Mandatory minimum measuring ranges, maximum uncertainties and time aggregation to be used are listed in the following Table 15.

5.12 Current Unbalance

Unbalance measurements apply only for 3 phase systems.

For Class A, the fundamental component of the current input signal shall be measured over a 10 cycle time interval for 50 Hz power systems.

This 10 cycle current unbalance measurement is marked flagged if either a voltage dip or swell (*see* **5.11**), or a voltage interruption (*see* **5.10**) occurs during this time interval.

For Class S, manufacturer shall specify the measurement method and time interval used.

Mandatory minimum measuring ranges, maximum uncertainties and time aggregation to be used are listed in the following Table 16.

5.13 Harmonic Current

The basic measurement of current harmonics is 10 cycles as defined in IEC 61000-4-7 are listed in the following Table 17.

Mandatory minimum measuring ranges, maximum uncertainties and time aggregation to be used are listed in the following Table 18.

5.14 Interharmonic Currents

The measurement methods, range and uncertainty to be applied to this parameter shall comply with IEC 61000-4-30.

6 POWER QUALITY MONITORING

6.1 General

This clause provides requirements for designing and performing statistical power quality monitoring surveys including permanent monitoring.

The most important task in any monitoring project is to clearly define the objectives of monitoring since the design stage. From these will come the parameters to be measured, the duration of the monitoring and the thresholds against which the parameters will be evaluated.

Table 3 Frequency Measuring Ranges, Uncertainty and Time Aggregation

(*Clause* 5.1)

Sl No. (1)	**Class** (2)	**Time Aggregation** (3)	**Maximum Measurement Uncertainty** (4)	**Measuring Ranges** (5)
i)	A	Not mandatory	± 10 mHz	42.5 Hz to 57.5 Hz
ii)	S	Not mandatory	± 50 mHz	42.5 Hz to 57.5 Hz

Table 4 Voltage Variations Measuring Ranges, Uncertainty and Time Aggregation

(*Clause* 5.2)

Sl No. (1)	**Class** (2)	**Time Aggregation** (3)	**Maximum Measurement Uncertainty** (4)	**Measuring Range** (5)
i)	A	10 cycles, 150 cycles, 10 min	± 0.1 % of U_c	10 % to 150 % of U_c
ii)	S	10 cycles, 150 cycles, 10 min	± 0.5 % of U_c	20 % to 120 % of U_c

NOTE — IEC 61000-4-30 excludes from the measurement chain any transducer not included into the measurement instrument and the refers the magnitude of the supply voltage to the declared input voltage U_{din} defined as the value obtained from the declared supply voltage by the transducer ratio. This standard refers the magnitude of the supply to the declared input voltage U_c.

Table 5 Flicker Severity Measurement Ranges, Uncertainty and Time Aggregation

(*Clause* 5.4)

Sl No. (1)	Class (2)	Time Aggregation (3)	Maximum Measurement Uncertainty (4)	Measuring Range (5)
i)	A	*see* IEC 61000-4-15	*see* IEC 61000-4-15	0.2 P_{st} to 10 P_{st}
ii)	S	*see* IEC 61000-4-15	Twice the permitted measurement uncertainty required by IEC 61000-4-15 under conditions described in **6**.	0.4 P_{st} to 4 P_{st}

Table 6 Voltage Unbalance Measuring Ranges, Uncertainty and Time Aggregation

(*Clause* 5.5)

Sl No. (1)	Class Name (2)	Time Aggregation (3)	Maximum Measurement Uncertainty* (4)
i)	A	10 cycles, 150 cycles, 10 min	± 0.15 % for both u_2 and u_0
ii)	S	10 cycles, 150 cycles, 10 min	± 0.15 % for both u_2 and u_0

NOTE — Measurement transformers, if present, may have a large impact on uncertainty of the unbalance.

Table 7 Harmonic Voltage Measurement Methods

(*Clause* 5.6)

Sl No. (1)	Class (2)	Measurement Method (3)	Notes (4)
i)	A	IEC 61000-4-7 Class I	10 cycle gapless harmonic subgroup measurement, denoted $U_{sg,h}$ in IEC 61000-4-7
ii)	S	IEC 61000-4-7 Class II	Gaps are permitted. The manufacturer shall either select 10 cycle harmonic group designated $U_{g,h}$ or 10 cycle subgroup designated $U_{sg,h}$ in IEC 61000-4-7

Table 8 Harmonic Voltages Measuring Ranges, Uncertainty and Time Aggregation

(*Clause* 5.6)

Sl No. (1)	Class (2)	Time Aggregation (3)	Maximum Measurement Uncertainty (4)	Measurement Range (5)
i)	A	10 cycles, 150 cycles, 10 min interval	IEC 61000-4-7 Class I	10 % to 200 % of Class 3 of IEC 61000-2-4
ii)	S	10 cycles, 150 cycles, 10 min interval	Twice the values specified by IEC 61000-4-7 Class II	10 % to 100 % of Class 3 electromagnetic environment in of IEC 61000-2-4

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*Absolute value

Table 9 Signal Voltage Reference Measurement Methods

(*Clause* 5.8)

Sl No. (1)	Mains Signalling Frequencies (2)	Reference Measurement Method (3)
i)	Below 3 kHz	IEC 61000-4-30
ii)	Above 3 kHz	IEC 61000-3-8

Table 10 Signal Voltage Measuring Ranges, Uncertainty and Time Aggregation

(*Clause* 5.8)

Sl No. (1)	Class (2)	Time Aggregation (3)	Mains Signalling Voltage (4)	Maximum Measurement Uncertainty (5)	Measurement Range (6)
i)	A	Not mandatory	Between 0.03 U_c and 0.15 U_c	± 5 % of the measured value	0 % to 15 % of U_c
			0.01 U_c and 0.03 U_c	± 0.15 % of U_c	
			Less than 0.01 U_1	—	
ii)	S	Not mandatory	Specified by manufacturer		Specified by manufacturer

Table 11 Voltage Interruption Reference Measurement Methods

(*Clause* 5.9)

Sl No. (1)	Class (2)	Measurement method (3)
i)	A	$U_{rms} = U_{rms}$ (½)
ii)	S	$U_{rms} = U_{rms}$ (½) or U_{rms} (1)

Table 12 Voltage Interruption Measuring Uncertainty

(*Clause* 5.9)

Sl No. (1)	Class (2)	Maximum Measurement Uncertainty (3)
i)	A	As per IEC 61000-4-30
ii)	S	As per IEC 61000-4-30

NOTE — Aggregation and measuring ranges are not applicable.

Table 13 Voltage Dip and Swell Reference Measurement Methods

(*Clause* 5.10)

Sl No. (1)	Class (2)	Measurement method (3)
i)	A	$U_{\text{rms}} = U_{\text{rms}}$ (½)
ii)	S	$U_{\text{rms}} = U_{\text{rms}}$ (½) or U_{rms} (1)

NOTES

1 The cycle duration for U_{rms} (½) depends on the frequency.

2 The U_{rms} (½) and the U_{rms} (1) value include, by definition, harmonics, interharmonics, mains signalling voltage etc.

3 The event magnitude shall be evaluated as the maximum difference between the reference voltage value and the U_{rms} measured during the event.

Table 14 Voltage Dip and Swell Measuring Uncertainty

(*Clause* 5.10)

Sl No. (1)	Class (2)	Maximum Measurement Uncertainty (3)	Measurement Range (4)
i)	A	Amplitude ±0.2 % of U_c, Duration measurement uncertainty ± 1 cycle	As per IEC 61000-4-30
ii)	S	Amplitude ±1.0 % of U_c, Duration measurement uncertainty ± 1 cycle for U_{rms}(½) or ± 2 cycles for U_{rms}(1) respectively	As per IEC 61000-4-30

Table 15 Magnitude of Current Measuring Ranges, Uncertainty and Time Aggregation

(*Clause* 5.11)

Sl No. (1)	Class (2)	Time Aggregation (3)	Maximum Measurement Uncertainty (Excluding Current Sensor Uncertainties) (4)	Measuring Range (5)
i)	A	In accordance with corresponding voltage channel	± 1 % of reading	10 % to 100 % of the specified full-scale rms current
ii)	S	Manufacturer or the user shall specify	± 2 % of reading	10 % to 100 % of the specified full-scale rms current

Table 16 Current Unbalance Measuring Ranges, Uncertainty and Time Aggregation

(*Clause* 5.12)

Sl No. (1)	**Class** (2)	**Time Aggregation** (3)	**Maximum Measurement Uncertainty*** (4)
i)	A	Same as supply voltage unbalance (*see* **5.6**)	Same as supply voltage unbalance (*see* **5.6**)
ii)	S	Specified by manufacturer	Specified by manufacturer

NOTE — The uncertainty of measurement transformers, if present, may have a large impact on uncertainty of the unbalance.

Table 17 Harmonic Current Measurement Methods

(*Clause* 5.13)

Sl No. (1)	**Class** (2)	**Measurement Method** (3)	**Maximum Measurement Uncertainty*** (4)
i)	A	IEC 61000-4-7, Class I	10 cycle gapless harmonic subgroup measurement, denoted $I_{sg,h}$ in IEC 61000-4-7. Measurement shall be made at least up to 50th order.
ii)	S	Specified by manufacturer	—

Table 18 Harmonic Current Measuring Ranges, Uncertainty and Time Aggregation

(*Clause* 5.13)

Sl No. (1)	**Class** (2)	**Time Aggregation** (3)	**Maximum Measurement Uncertainty** (4)	**Measurement Range** (5)
i)	A	10 cycles, 150 cycles, 10 min	IEC 61000-4-7 Class I	10 % to 200 % of Class 3 of IEC 61000-2-4
ii)	S	10 cycles, 150 cycles, 10 min, 2 h interval	Specified by manufacturer	Specified by manufacturer

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*Absolute value

6.2 Statistical Applications

Usually PQ parameters show variations overtime and then statistical applications are required:

a) To compress a large number of measured values; and

b) To compute power quality indices for benchmarking.

A statistical analysis should be done with homogeneous values: same measurement time interval, same measurement data, same network etc.

Statistics computation is based on classification of the measured values.

For each parameter, the user defines a normal range of variation and the decision to include or not, flagged data. The normal range of variation is then divided into several bins of equal width (IS 61000-4-30).

6.2.1 *Power Quality Indices*

One single point on the network may be characterized by two kinds of power quality statistical indices depending on the phenomena concerned:

a) Statistical indices like percentiles, maximum or mean values over a period of time (IEC TR 61000-3-6 for harmonics or IEC TR 61000-3-7 for flicker); and

b) Event counting and tabulating.

6.2.2 *Monitoring Objectives*

The objectives of the monitoring are the following:

a) PQ evaluation and assessment: To evaluate and assess the electrical environment at a particular location; and

b) Planning the connection of new equipment: To predict future performance of equipment or power quality mitigating devices that are planned to be connected within an installation.

Troubleshooting: To diagnose incompatibilities between the electric power source and the existing equipment connected within an installation.

NOTES

1 Power quality is assessed by a comparison between the results of measured PQ parameters, and the corresponding limits. If not otherwise agreed, for the scope of this standard these limits are the ones set in IS 17036 or IEEE 519-2014 or prevailing CEA guidelines.

2 If permanent monitoring is not already available, when PQ measurements are considered necessary to assess compliance of the supply against contract terms the monitoring survey design needs to be agreed by the concerned parties.

The monitoring survey design should indicate how the financial cost of the measurements is to be borne by the concerned parties.

The agreement would also address the subject of data access and confidentiality, for example, the party carrying out the PQ measurements might not be the same party that has to analyse the data and assess contract conformity.

There might be a need to consult third parties.

6.3 Monitoring Locations

The choice of locations to install power quality monitors will be dependent upon the objective of the survey.

For compliance monitoring related to service contracts, a monitoring location should be agreed to by all parties to the contract in advance. This is typically defined as the point of common coupling (PCC) between the customer and the system:

If the monitoring objective is to diagnose an equipment performance issue, then the monitor should be placed as close to the load as possible supplemented by monitoring further at the PCC to facilitate origin of PQ parameters which might be the cause of equipment performance issues.

NOTE — For most applications, the point closest to the load will not be further than the switchgear terminal feeding the load.

6.4 Quantities to Measure

The quantities to measure shall be defined according to the monitoring objectives and relevant compliance standard.

a) For general surveys it will be necessary, in order to conserve memory space, to identify a priority order for the quantities to monitor. Usually, the only issues affecting this decision are instrument storage capabilities and communication time/cost impacts; and

b) In general, customers are responsible for the current that their equipment draws from or injects into the system and the supplier is responsible for the supply voltage. This fact can be used as the basis for deciding when to measure also currents.

The measurement of current can be invaluable in determining the sources/cause of power quality events since it can help to determine if the cause of the event is upstream or downstream of the measuring instrument. This is particularly true for voltage dips.

6.5 Measuring Equipment Connection

The decision for connecting the measuring equipment include:

a) Single-phase versus three-phase measurement;

b) Line-to-line versus line-to-neutral or line-to-ground connection; and

c) High side versus low side measurement near transformers.

The connection should be made in a way that is consistent with the requirements or connection of the affected equipment – taking into account transformer connection issues.

When voltage dips and swells are monitored, all phases shall be monitored. When measuring steady state phenomena, such as for example, harmonics and flicker, single-phase measurements may be made if phenomena are expected to be reasonably balanced. This assumption should be checked by performing a temporary three-phase measurement.

NOTE — When general surveys are being performed with a three-phase connection and/or there are several voltage transformations downstream from the monitored location, connecting the measurement equipment from line-to-neutral on grounded systems is recommended because the line-to-line values can often be derived either in the instrument or off-line.

Where this is not the case, the connection mode of the monitoring instrument should be chosen taking into account both the connection mode of the potentially affected equipment and the successive voltage transformations downstream.

6.5.1 *Power Quality Indices Monitoring and Reporting Period for Contractual Applications of PQ Measurements*

PQ parameters show variations overtime, therefore a meaningful minimum monitoring period shall be adopted.

Table 19 Recommended Minimum Assessment Periods and Frequency of Reporting

(*Clause* 6.5)

Sl No. (1)	**Parameter** (2)	**Minimum Assessment Period** (3)	**Recommended Frequency of Reporting to Authorities** (4)
i)	Supply frequency	1 week	Quarterly
ii)	Magnitude of supply voltage	1 week	Monthly
iii)	Single rapid voltage change	Under consideration	Under consideration
iv)	Flicker	1 week	Quarterly
v)	Supply voltage unbalance	1 week	Quarterly
vi)	Harmonic voltages	1 week	Quarterly
vii)	Interharmonic voltages	Under consideration	Under consideration
viii)	Main signalling voltages	1 day	Quarterly
ix)	Voltage interruptions	1 year	Yearly with monthly sliding window
x)	Dips and swells	1 year	Yearly with monthly sliding window
xi)	Magnitude of current	1 week	Quarterly
xii)	Current unbalance	1 week	Quarterly
xiii)	Current harmonic	1 week	Quarterly
xiv)	Current inter-harmonic	Under consideration	Under consideration

NOTE — The recommended frequency of reporting is provided from a power quality assessment standpoint. For contractual obligations such as dispute resolution and/or compliance to standards, the recommended frequency of reporting may be more stringent as decided by the regulatory authorities.

ANNEX A

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No./Other Standards	*Title*
IS 14700 (Part 3/ Sec 3) : 2018/IEC 61000-3-3 : 2013	Electromagnetic compatibility (EMC): Part 3 Limits, Section 3 Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply system, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection (*second revision*)
IS 14700 (Part 4/ Sec 7) : 2017/IEC 61000-4-7 : 2009	Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 7 General guide on harmonic and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto (*first revision*)
IS 14700 (Part 4/ Sec 15) : 2018/IEC 61000-4-15 : 2010	Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 15 Flickermeter — Functional and design specifications (*second revision*)
IS 17036 : 2018	Distribution system supply voltage quality
IEC 61000-2-4 : 2002	Electromagnetic compatibility (EMC) — Part 2-4: Environment — Compatibility levels in industrial plants for low-frequency conducted disturbances
IEC TR 61000-3-6 : 2008	Electromagnetic compatibility (EMC) — Part 3-6: Limits — Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems
IEC TR 61000-3-7 : 2008	Electromagnetic compatibility (EMC) — Part 3-7: Limits — Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems
IEC 61000-3-8 : 1997	Electromagnetic compatibility (EMC) — Part 3: Limits, Section 8 Signalling on low-voltage electrical installations — Emission levels, frequency bands and electromagnetic disturbance levels
IEC 61000-4-30 : 2015	Electromagnetic compatibility (EMC) — Part 4-30: Testing and measurement techniques — Power quality measurement methods
IEC 61180 : 2016	High-voltage test techniques for low voltage equipment — Definitions, test and procedure requirements, test equipment
IEEE 519 : 2014	IEEE recommended practice and requirements for harmonic control in electric power systems

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Basic Electrotechnical Standards Sectional Committee, ETD 01

Organization	*Representative(s)*
Central Electricity Authority, New Delhi	Ms Vandana Singhal **(*Chairperson*)**
ABB India Limited, Bengaluru	Shri Srikanth Mulam
Adani Electricity Limited, Mumbai	Shri Hiren Tailer
AYT Engineering Private Limited, Mumbai	Shri Saurabh Tripathi Shri M. Shahzad Alam (*Alternate*)
BSES Yamuna Power Limited, New Delhi	Shri Gaurav Sharma Shri Ashish Kumar Joshi (*Alternate*)
Calcutta Electric Supply Corporation Limited, Kolkata	Shri Nilanjan Saha Shri Shamik Purkayastha (*Alternate*)
Central Electricity Authority, New Delhi	Ms Shivani Sharma Ms Pooja Jain (Representative)
Central Power Research Institute, Bengaluru	Dr Pradeep M. Nirgude
Central Public Works Department, New Delhi	Shri M. K. Verma
CSIR - National Physical Laboratory, New Delhi	Ms Priyanka Jain
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Member Secretary
Shri Ashok Kumar
Scientist 'B'/Assistant Director
(Electrotechnical), BIS

(*Continued from second cover*)

IS No./Other Standards	*Title*
IEC 61180 : 2016	High-voltage test techniques for low voltage equipment — Definitions, test and procedure requirements, test equipment
IEC 62586-2 : 2017 2008 (JCGM/WG1/100)	Power quality measurements in power supply systems — Part 2: Functional tests and uncertainty requirements
ISO/IEC Guide 98-3 :	Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM : 1995)
IEEE 519 : 2014	IEEE Recommended practice and requirements for harmonic control in electric power systems
IEEE 1159 : 2019	Recommended practice for monitoring electric power quality
Other Publication	Handbook of power quality edited by A. Baggini published by John Wiley and Sons, 2008

The composition of the Committee responsible for formulation of this standard is given in Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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